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University of Helsinki, Finland

**Theoretical knowledge for treatment decisions
among Finnish dentists**

Mia Heinikainen

Academic dissertation

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*"Each moment away from you seems forever,
each moment together passes much too
quickly".
(George Werner)*

To Risto, Veera, and Roope

ABSTRACT

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This study determined theoretical knowledge for treatment decisions in restorative dentistry, periodontology, endodontology, and oral implantology by Finnish dentists. These decisions were compared to international treatment recommendations and guidelines which exist in periodontology, endodontology, and oral implantology. With stratified randomisation, 400 general practitioners (GPs) were selected among the members of the Finnish Dental Association. In total, eight clusters were formed according to main employment (public or private sector), gender, and age. In addition, 47 dental teachers (DTs) were included. Data were collected with a pre-tested questionnaire, in which treatment options related to clinical cases from four disciplines were presented in detail to allow respondents to choose the optimal treatment decisions from among the given alternatives. Based on their answers, a Treatment Decision Competency Score (TDCS) was developed to describe dentists' competency in making optimal treatment decisions in three disciplines which have existing international recommendations and guidelines. The overall response rate for GPs was 78% and for DTs 74%. The variation in theoretical knowledge for treatment decisions in three dentist groups was largest in restorative dentistry and in oral implantology, with private dentists and DTs more frequently preferring indirect restorations and in most cases, implant therapy than did public dentists. A greater number of continuing education days was associated with dentists' preference for indirect restorations in restorative treatment, with their preference for surgery in periodontology, and with their preference for implant therapy for patients with oral and medical contraindications in implantology. Finnish dentists' theoretical knowledge for treatment decisions in periodontology, endodontology, and in implantology mostly agreed with international recommendations and guidelines. The TDCS revealed that male dentists in the private sector chose optimal treatment decisions more frequently than did other dentist groups. Development of national and international recommendations could help clinicians in diagnosing and decision-making to optimise dental treatment decisions.

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ABBREVIATIONS

AADR	American Association of Dental Research
AADS	American Association of Dental Schools
AAE	American Association of Endodontists
AAP	American Academy of Periodontology
ADA	American Dental Association
AHRQ	Agency for Healthcare Research and Quality
BDA	British Dental Association
CDA	California Dental Association
CDCDI	Consensus Development Conference on Dental Implants
CE	continuing education
CPID	<i>Clinical Periodontology and Implant Dentistry</i>
CRIT I	Consensus Report Implant Therapy I
CRIT II	Consensus Report Implant Therapy II
CRWWP	Consensus Report from the 1996 World Workshop of Periodontology
DMFT	number of decayed, missed, filled teeth
DTs	dental teachers
EBD	evidence-based dentistry
EBM	evidence-based medicine
ESE	European Society of Endodontology
FDI	World Dental Federation
GPs	general practitioners
IADR	International Association for Dental Research
KELA	Social Insurance Institution (FIN)
NAM	National Agency for Medicines (FIN)
NBH	National Board of Health (FIN)
NIH	National Institutes of Health (USA)
NIOM	Scandinavian Institute of Dental Materials
RCT	randomised controlled trial
STAKES	National Research and Development Centre for Welfare and Health
TCP	<i>Textbook of Clinical Periodontology</i>
TDCS	Treatment Decision Competency Score
WHO	World Health Organization

In this study tooth names follow the ISO / FDI / WHO approved system, e.g., 25 = upper left second premolar.

LIST OF ORIGINAL PUBLICATIONS

The thesis is based on the following original articles referred to in the text by their Roman numerals.

- I Heinikainen M, Vehkalahti M, Murtomaa H.
Re-treatment decisions for failed posterior fillings by Finnish general practitioners.
Community Dental Health 2002; 19: 98-103.
- II Heinikainen M, Vehkalahti M, Murtomaa H.
Periodontal treatment practices of Finnish dentists.
Journal of Clinical Periodontology 2002; 29: 1101-1106.
- III Heinikainen M, Vehkalahti M, Murtomaa H.
Retreatment in endodontics: treatment decisions by general practitioners and dental teachers in Finland.
International Dental Journal 2002; 52: 119-124.
- IV Heinikainen M, Vehkalahti M, Murtomaa H.
Influence of patient characteristics on Finnish dentists' decision-making in implant therapy.
Implant Dentistry 2002; 11: 301-307.

In addition, some unpublished data are presented.

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INTRODUCTION

Treating patients is based on a chain of treatment decisions: large and small, but always numerous. This means thousands of daily treatment decisions in Finland alone, and billions worldwide.

Making a treatment decision is a demanding task for a dental professional, resulting in considerable variation in treatment practices. This variation has been well verified (Rytömaa et al. 1979, Elderton and Nuttall 1983, Grembowski et al. 1990). The basis of treatment decisions, including the psychology of decision-making, decision theory, and decision analysis have been discussed in an International Symposium (Kantor 1992), but reasons leading to different treatment decisions are not yet well defined. Interest in treatment recommendations and guidelines in dentistry seems to be increasing. Currently, the number of recommendations is considerable, but the discussion is actively ongoing.

In Finland, the total number of working-age dentists is around 4800, 10% of them specialised in clinical disciplines (Vaalgamaa and Ohtonen 2001). The dental care system consists of the public and the private sector, with approximately equal numbers of dentists in each. Up to the present day, private dentists, mainly in urban areas with larger numbers of inhabitants, have been treating mostly adults, whereas the public dentists' primary duties have been treatment of children and adolescents. In rural areas, however, public dentists usually treat all those residing in the community, including adults and elderly people.

During the last few years, the system has undergone a marked change based on amendment of the Primary Health Care Act. From December 2002, public dental care is supposed to be available for all inhabitants of the community. Consequently, reimbursement by the Social Insurance Institution (KELA) for dental care in the private sector now covers all age-groups. This implies that in most communities patients can decide which dental delivery sector they prefer.

Restorative treatment and periodontology are the most common treatments in both the public and private sector. In the public dental service, 32% of all procedures are restorative, exceeding 50% for adults (Läärä et al. 2000). In the private sector, no official statistics are collected on all treatments, but KELA statistics are available on subsidised dental care for those under 46 years old. Restorative procedures dominate also here: 30% of all subsidised treatments are restorative. Further, 10% is allocated for

periodontal treatment and 7% for endodontic treatment (KELA 2003). Prosthodontic treatment is not subsidised by the KELA.

Money and time spent on dental care are valuable for the patient; but a positive outcome is not always a matter of course. Optimal treatment decisions are thus an essential part of dentist's work, both for the patient's treatment outcome and for the patient's and society's economic interest. In addition to the economic cost of treatment, dental treatment can sometimes add a biological burden on the patient, e.g., pain and inconvenience. Further, the dentist has an ethical obligation to render optimal treatment available to patients, at least by providing information about available optimal treatment alternatives. It is thus important to understand variation in treatment decisions and factors related to it in order to optimise treatment decisions and thus establish a basis for high-quality treatment.

REVIEW OF THE LITERATURE

Decision-making in dentistry

Clinical decision-making is "a multifactorial process involving the assimilation of information from clinical experience, relevant research, and patient preferences and goals for anticipated outcomes" (Matthews 1994), making the investigation of treatment decisions a demanding task. Clinical decision-making involves the dentist's assessment of probabilities for different outcomes of treatment options and choices by the patient. In dental decision-making, the dentist is described as a central character but is not isolated from environmental or patient factors (Kay and Nuttall 1995a) (Figure 1).

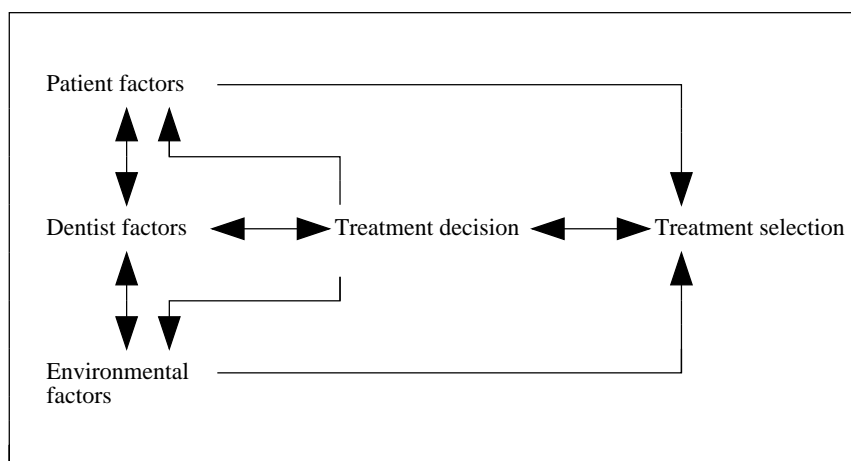


Figure 1. A model of the dental treatment decision-making process. Reprinted from *Br Dent J*, Vol 178, Elizabeth Kay and Nigel Nuttall, Clinical decision making - an art or a science? Part II: Making sense of treatment decisions, pages 113-116, Copyright 1995, with permission from the *British Dental Journal*.

A definition of decision-making is given by Simpson et al. (1981): "a structured approach to guide a person or group to workable solutions of a problem, to make plans, and to evaluate data". Further, the decision-making frame contains the identification of players in the process, including descriptions of their roles, performance expectations, and boundaries of rights and obligations: clear definition of objectives, collection of data,

analysis of their relevance, and study of possible alternatives with evaluations of their consequences (Tuzman and Cohen 1992).

Decision-making is a complex process involving many factors. These have been classified as dentist-factors, patient-factors, and the decision-making situation (Bader and Shugars 1997). Costs and benefits, attitudes and values, and actualisation of expectations are the issues and questions most relevant to treatment decisions in general dental practice (Kay and Blinkhorn 1996). Further, the dentist/patient relationship, the dentist's personal way of treating patients, the probability of success of treatment, patient appointments, and financial means are considered common factors which can affect decision-making (Kay and Nuttall 1995b). Moreover, patients' wishes and prognosis for treatment are offered as other important factors in decision-making (Kronström et al. 1999a).

Strategies for clinical decision-making

Decision analysis is a formalised way to transfer a patient's preferences to the dentist's decision-making (Weinstein and Fineberg 1980). This analysis, first applied in the medical field to problems of diagnosis and clinical judgement, patient management, and treatment of disease (McCreery and Truelove 1991), is nowadays addressed to the many disciplines of dentistry (Anusavice 1992, Holzman and Kornman 1992). In the analysis, the decision-making process is laid out as a decision tree where decisions lead to an outcome (Carter 1992, Kent 1992, Rohlin and Mileman 2000). The structure of the decision tree is a map of all possible events that could happen after someone's having made a particular decision (Weinstein and Fineberg 1980, Hall et al. 1998). In preparing a treatment decision, the tree requires information on all available alternatives, and on all possible outcomes and their probabilities, and finally, on the patient's preference for each outcome (Kay and Nuttall 1995c). Decision analysis is a carefully engineered conversation that focuses attention on key decision aspects to promote the rational use of existing knowledge and thus improve decision-making, but elements such as patient-specific factors cannot be properly anticipated and incorporated into the generic model. These factors need to be identified and efficiently assessed in the context of specific clinical decisions (Holzman and Kornman 1992).

Rational decision-making (Figure 2), as presented by Kay and Nuttall (1995d), can be considered one application of decision analysis. In order to make good decisions on a rational basis, a dentist must take into account existing knowledge of all possible treatment options and have a comprehensive view of all the possible consequences of each available treatment and the ability to determine values for each possible outcome, as well as the ability to rank values from the most desired to the least desired outcome.

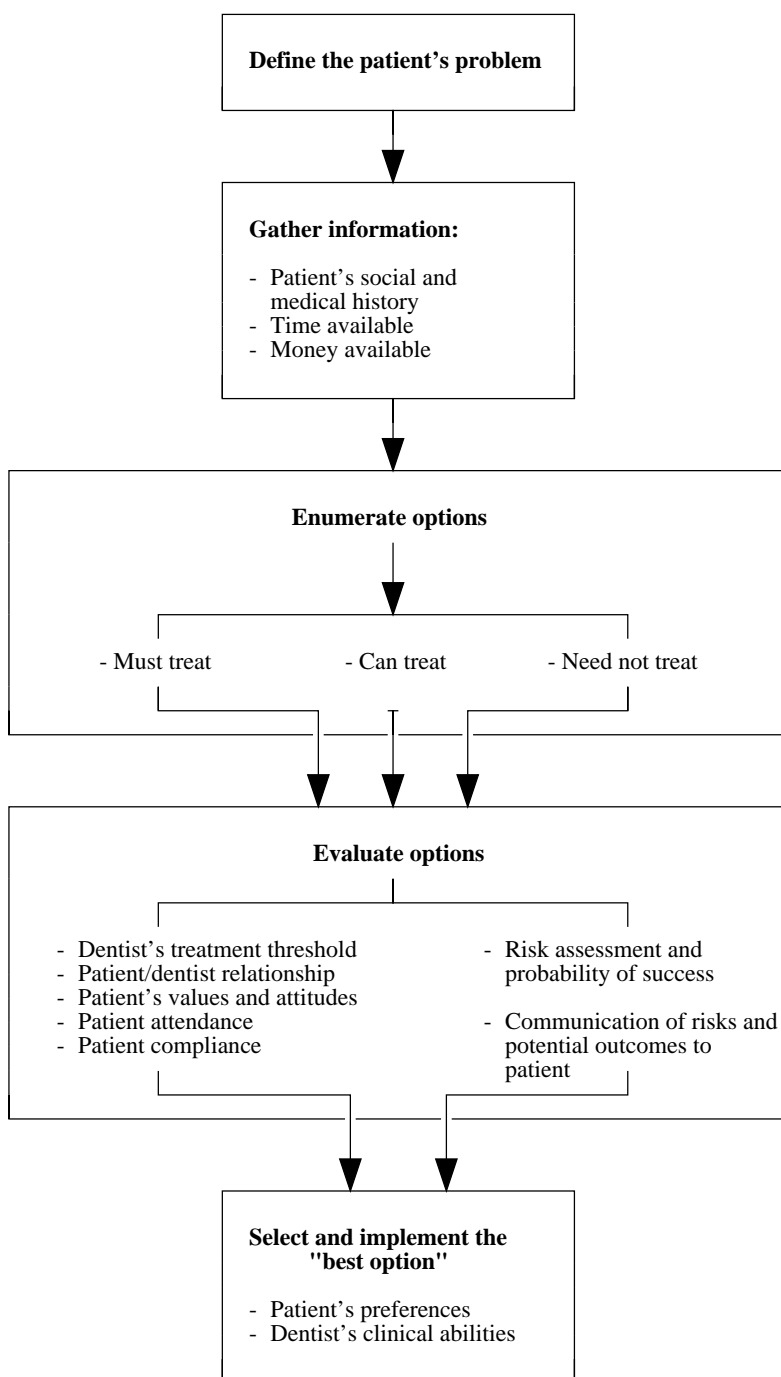


Figure 2. Rational decision-making. Modified from *Br Dent J*, Vol 178, Elizabeth Kay and Nigel Nuttall, Clinical decision making - an art or a science? Part IV: Decision making in dental practice: a case study, pages 269-273, Copyright 1995, with permission from the *British Dental Journal*.

Rational decision-making is an attempt to formalise dentists' treatment decisions, focusing the dentist's thinking on the most important factors which have an influence on treatment decisions. The required knowledge, information, and dentists' skills are based on undergraduate training or continuing education (CE).

Rational decision-making will influence mainly the treatment planning process. It will help dentists to define the treatment options available and the patient and dentist values involved; then the decisions made will be successful not only from a clinical point of view but will also satisfy the patient (Kay and Nuttall 1995d).

Modern information technology is nowadays available also for dental care. In order to achieve an optimal high-quality diagnosis, a decision-support computer program can serve as an independent expert. Such programs based on standardised representation of knowledge and inference following the general principles of dental decision-making may assist dentists in their treatment decisions.

Evidence-based health care

The philosophy of the evidence-based approach originates from discussions in the mid-19th century in central Europe (Sackett et al. 1996) and has lately been established in several fields of medicine, e.g., in general medicine, paediatrics, pharmacotherapy, and dentistry. In recent years, the number of research papers has increased considerably, as well as the patients' demand for assurance of treatment effectiveness. Use of the evidence-based approach means that the treatment provided is justified by the best available scientific evidence.

The evidence-based approach is defined as "the conscientious, explicit, and judicious use of the current best evidence in making decisions about the care of an individual patient" (Sackett et al. 1996). It is also defined as "a straightforward, systematic process, which helps the clinician and researcher evaluate the relevant information regarding diagnosis, treatment, prognosis, and experimental decisions" (Newman 1996). Evidence-based medicine (EBM) involves integrating clinical expertise with the best available clinical evidence derived from systematic research (Sackett et al. 1996, Richards et al. 1997). The practice of EBM is described as a process of self-directed learning in which caring for patients creates a need for clinically important information about diagnoses, prognoses, treatment, and other health care issues (Straus and Sackett 1998). Practically speaking, EBM is an approach to decision-making in which the clinician uses the best evidence available, in consultation with the patient, to decide upon the treatment alternative which suits that patient best.

The beginning of evidence-based dentistry (EBD) followed development of the evidence-based approach in medicine during the 1970s (Burt 1999). The evidence-based approach requires that investigators emphasize the importance of unbiased data (evidence) and use specific rules of evidence appraisal to quantify their recommendations in treatment decisions (McGuire and Newman 1995). It also attempts to answer clinical questions based on critical review of the best available scientific evidence with the highest accuracy, together with the dentist's clinical experience and scientific knowledge (Abt 1999, Chambers 1999). One of the best-known international sources of evidence is The Cochrane Collaboration, which builds and maintains a database of updated systematic reviews or randomised controlled trials (RCT) in health care and makes these accessible electronically. Its main product is The Cochrane Library (Cochrane 2003).

Traditional and evidence-based decision-making

A framework and practice for clinical decision-making is created by dental education during undergraduate training. Instructions of dental teachers (DTs) and their preferences may influence treatment decisions, although students' dental knowledge is also based on theory presented in textbooks. After graduation, in clinical practice, dentists' treatment decisions are largely based on clinical experience, learning from successes and mistakes, and training; sometimes decisions are based on general knowledge of similar or of corresponding situations, in the traditional manner.

The traditional model of practice describes an exchange between the patient and dentist (Figure 3) (Anderson 2000). According to this model, the patient presents a complaint, and the dentist provides advice, decisions, and treatment, taking into account all the background he or she can obtain in the available time; a working plan is designed based on knowledge of pathophysiological processes or memory of similar clinical problems. The traditional decision-making consists of three phases: 1) the making of a diagnosis, 2) a decision about intervention, 3) selection of the treatment from among the alternatives (Bader and Shugars 1992). In a later traditional model (Anderson 2000) the last two phases are combined. In both models, treatment decisions are influenced by dentists' training, personal experience, consultation, and continuing education.

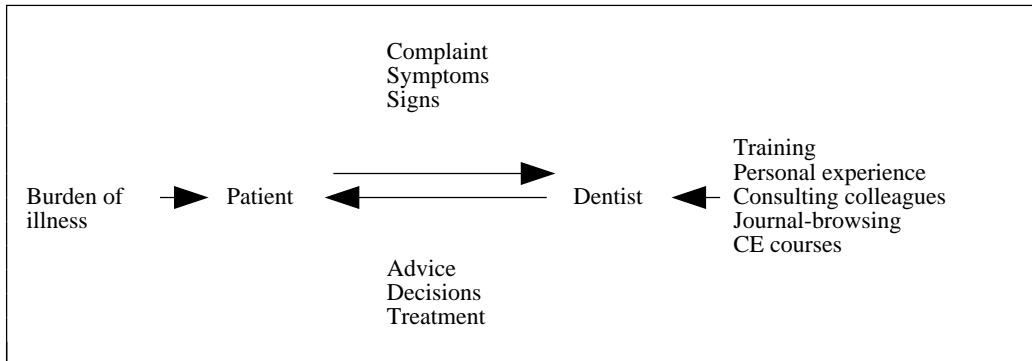


Figure 3. Traditional model of practice. Modified from *J Prosth Dent*, Vol 83, James D. Anderson, Need for evidencebased practice in prosthodontics, pages 58-65, Copyright 2000, with permission from The Council of the *Journal of Prosthetic Dentistry*.

The evidence-based model (Figure 4) has the same origin as the traditional one: a patient's problem. The first step is to convert the problem into answerable questions to define the key elements relating to diagnosis, prevention, therapy, prognosis, self-improvement, or causation, making any electronic search easier (Straus and Sackett 1998, Anderson 2000, Sutherland 2001a).

The second step is the use of comprehensive search methods to find the best evidence from relevant studies (Newman 1996, Straus and Sackett 1998, Anderson 2000). It is important that all pertinent studies are included, with no important ones neglected (Sutherland 2001b). Careful consideration of various stages of disease, the patient's age-group, and the language of the reports are essential elements to define when selecting explicit inclusion criteria.

In the third step, dentists should assess the validity and relevance of reported findings as well as the variation between relevant studies (Anderson 2000, Sutherland 2001c, 2001d). The best evidence of treatment efficacy is based on findings from RCTs, with blind comparison in an appropriate sample of subjects (Coulter 2001). In addition, "for many questions about the relationship between the funding and organisation of healthcare and patient outcomes, a well-conducted cohort study is the most appropriate form of research design" (Gray 1997).

Finally, the evidence obtained is integrated with dentists' clinical experience and their knowledge of patients' unique features, rights, and expectations, to allow them to reach an optimal treatment decision (Straus and Sackett 1998, Anderson 2000). Thus, an evidence-based treatment decision integrates the best scientific evidence, clinical assessment, and patient preferences.

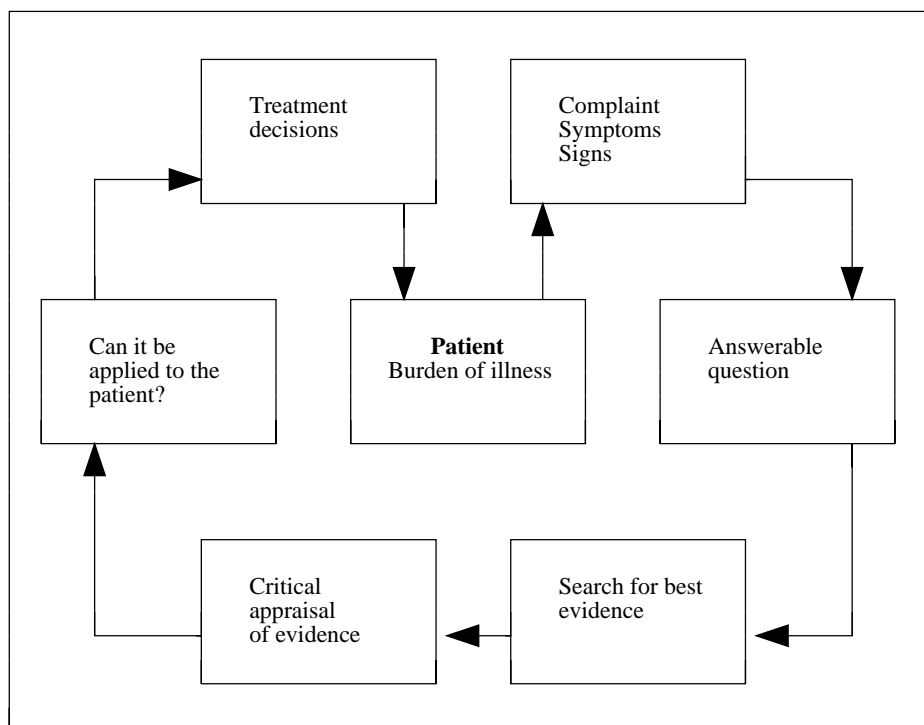


Figure 4. Model of evidence-based practice. Reprinted from *J Prosth Dent*, Vol 83, James D. Anderson, Need for evidencebased practice in prosthodontics, pages 58-65, Copyright 2000, with permission from The Council of the *Journal of Prosthetic Dentistry*.

Evidence-based decision-making consists of an explicit quantitative calculation, and both statistical and clinical significance must exist. In traditional decision-making, the risk/benefit determinations are based on qualitative measurements (Newman 1996). Further, in traditional decision-making, treatment decisions are not based on controlled or blind trials, whereas the evidence-based approach requires identification of all types of bias prior to decision-making (Newman 1996).

Strength of evidence

Strength of evidence is classified into five categories (Gray 1997). The two strongest, evidence type I and II, are derived from well and properly designed RCTs, systematic review of RCTs, and well-conducted, prospective cohort studies. Type III and IV evidence comes from well-designed trials without randomisation, from cohort-, time series-, or matched case-control studies, and evidence from well-designed non-experimental studies from more than one research group. Type V evidence is formulated according to the opinions of respected authorities based on clinical evidence, descriptive studies, or reports of

expert committees (Gray 1997). Currently the amount of scientific information in dentistry is vast, but only a small amount of high-quality evidence, as well as a limited number of evidence-based treatment recommendations, is available (Bader and Shugars 1995, Sutherland and Walker 2001).

Clinical practice guidelines and recommendations

Updating professional information

Dentistry is a fast-developing, dynamic science, demanding that all dentists constantly update their skills and knowledge of new technology and scientific advances. Dental teachers are in a key position to prepare their students to achieve a positive attitude towards continuing education and to encourage self-directed learning throughout their professional lives.

CE is "concerned with the maintenance of professional competence by continuous updating of knowledge and skills," and there is an ethical obligation for each dentist to participate (European Commission 1996). Accordingly, the commission declares that the dentist should not rely solely on knowledge gained during undergraduate training if patients are to be provided with the highest standard of care throughout the dentist's practising life. In Finland, the dentists' obligation to maintain their professional knowledge is defined by law (Public law: Act on Health Care Professionals 559/1994), but participation in CE is voluntary.

Finland has a long tradition of dental education. The Finnish Dental Society Apollonia was established, among other societies for continuing education, over 110 years ago (Paunio et al. 1992). Although currently CE is offered also by universities and private dental companies, the Finnish Dental Society Apollonia (2002) still plays the main role in arranging CE. Most common are one-day courses (79 in 2002); CE courses cover most disciplines (e.g., restorative dentistry, periodontology, endodontology, oral surgery), and some include hands-on training. The annual dental congresses organised in co-operation with all national dental associations update the knowledge of some 5000 working-age dentists, technicians, oral hygienists' and dental assistants. About 10 000 dental personnel participated in CE arranged by the Finnish Dental Society Apollonia in 2002. Many larger community health centres offer CE for their personnel, arranging CE locally, for example as presentations in monthly meetings. Dental journals, videos, and modern information technology have increasingly become valuable sources of CE.

Good clinical practice

Clinical practice guidelines are defined as "systematically developed statements to assist practitioners and patients in arriving at decisions on appropriate health care for specific clinical circumstances" (Field and Lohr 1990). They are tools for assisting in dentists' clinical decision-making by enhancing clinical judgement and expertise (Sutherland et al. 2001). Credible and useful guidelines employ the evidence-based process to assemble, organize, and synthesize the best available evidence from clinical research. This evidence is then integrated with clinical expertise from a number of health care professionals to develop clinical recommendations for good clinical practice (Sutherland et al. 2001). Guidelines in dentistry are anticipated to reduce treatment variability and to ensure the quality and cost-effectiveness of care (Bray and Williams 1997, Greenhalgh 2002).

Guidelines in health care

Practice guidelines are presently produced through many organizations and agencies worldwide. In many countries, e.g., Scotland, the Netherlands, France, and the USA, there also exist national guidelines, statements, and recommendations of good clinical practice (Mäkelä and Kunnamo 1997). In the USA, the Agency for Healthcare Research and Quality (AHRQ) develops scientific information using, for instance, MEDLINE and the register of Cochran Controlled Trials for other agencies and organizations on which to base clinical guidelines. Currently, the AHRQ has 19 guidelines for general medicine (AHRQ 2003). In Scotland, national recommendations exist - the SIGN guidelines, which are nationally accepted, clinically reviewed, and adopted at the local level (SIGN 2003). The SIGN presents a total of 60 evidence-based guidelines, including cancer, cardiovascular diseases, and mental health. Many other international guidelines are available on web sites, for example treatment of various cancer types (Cancercare 2003).

In Finland, there exists a "Good Clinical Practice" project (Käypä hoito) (Duodecim 2003) which aims to develop and update national treatment recommendations and guidelines for various disciplines in medicine (Mäkelä and Kunnamo 1997, Nikkarinen and Brommels 1998). This register includes completed guidelines for treatment of 48 diseases, the next 40 being still in preparation.

Guidelines in dentistry

Development of evidence-based reviews, guidelines, and statements for dentistry began in the last decade, but the number of international treatment guidelines or statements is still not large. The Cochrane Oral Health Group (2003) has listed 24 reviews for dentistry and about 30 protocols which are under preparation. Of the reviews, five are related to preventive treatment, seven to oral surgery or implantology, six to mucosal disorders or oral cancer, two to diseases of the temporo-mandibular joint, and one to each of these:

orthodontic treatment, periodontology, endodontology, and restorative treatment. The World Dental Federation (FDI) has listed in their web sites over 400 guidelines or statements relating to dental treatment, seven consensus statements by the American Association of Dental Research (AADR), and about 15 international guidelines or statements from the International Association of Dental Research (IADR) and World Health Organization (WHO), including international classification of diseases into dentistry and stomatology (FDI 2003). Furthermore, the National Institutes of Health (NIH 2003) has listed eight consensus statements on dental treatment. The American Dental Association (ADA 2003) has published about 50 national guidelines or statements, and the British Dental Association (BDA 2003) has published about 25 guidelines or statements. The Scottish SIGN guidelines include two reports relating to dentistry; one on prevention of dental caries in children at high risk and the other on management of unerupted and impacted third molars (SIGN 2003).

Locally created and accepted treatment recommendations have been shown to improve clinical practice concerning treatment decisions, as do the nationally accepted ones (Grimshaw and Russell 1993). In Finland, national recommendations by the National Board of Health (NBH) have been provided since the School Dental Care Act in 1956. The NBH gave its recommendations concerning the use of fluorides in prevention of dental diseases (1969), concerning dental care in community health care (1972), dental treatment of adolescents (1985), and selection of filling materials in restorative dentistry (1987). Its recommendation on the use of fluoride was later revised by the National Research and Development Centre for Welfare and Health (STAKES) (Widström 1996). The National Agency for Medicines (NAM) has published quality criteria for dental equipment (1998), standards of practice for hygiene and infection protection (2003), and criteria for several commonly used dental materials, including information on their possible health risks (Widström and Forss 1996, Widström et al. 1997, Forss et al. 1998). In Finland, the first national recommendation for good clinical practice in dentistry, regarding oral cancer, has recently been completed (Duodecim 2003); furthermore, in the most recent recommendation, dentists have agreed with physicians to provide information about anti-tobacco counselling (Duodecim 2003). Some Finnish communities have begun to develop local recommendations in order to unify treatment practices in public dental care. The national dental development project, SUHAT, offers a forum for further discussions and development of guidelines.

Recommendations in restorative dentistry

Restorative treatment accounts for the majority of dental care expenditures, but updated, internationally acknowledged guidelines concerning restorative re-treatment decisions or material selection are lacking, although some efforts have been made to create them. These include detailed criteria concerning the placement and replacement of dental restorations provided by an international group of dental researchers, educators, and practitioners in the USA (Anusavice 1989). An international symposium by the IADR (1990) discussed re-restorations of teeth, material failures, and secondary caries. Later efforts include a statement of effects and side-effects of restorative materials by the NIH (1991), a recommendation designed to aid investigators in planning and executing clinical research on dental materials (Mitchem and Tyas 1992), and, most recently, the Cochrane Review on ceramic inlays for posterior teeth (Hayashi and Yeung 2003).

The Nordic Countries have a long common history relating to material selection and recommendations in dental care. Since 1972 the Nordic Institute of Dental Materials (NIOM) has been testing dental materials and giving recommendations accordingly (NIOM 2003). In recent years, the European Union has suggested common standards for dental materials, for which the NIOM serves as a regulatory body. Despite these attempts, detailed knowledge of the precise influence of numerous material-, and dentist-, and patient factors on the quality of dental restoration is still lacking (FDI Statement 2001).

Recommendations in periodontology

The California Dental Association (CDA 1977) has published Guidelines for the Assessment of Clinical Quality and Professional Performance in periodontology to aid clinicians who deal with clinical examination and treatment recording, root planing, scaling, and periodontal surgery, and finally, those who need quality evaluation criteria for periodontal treatments. An international statement on the role of supportive periodontal therapy in the treatment of periodontal diseases was published by the American Academy of Periodontology in 1998 (AAP 1998). The Consensus Report from the 1996 World Workshop of Periodontology, the CRWWP (1996), offers a detailed, evidence-based, extensive analysis of current theory and practice in periodontics. The Consensus Report includes more than 100 tables and nearly 5000 references. Periodontal treatment is discussed in relation to epidemiology and diagnosis, prevention, medically compromised patients, mucocutaneous disorders, non-surgical and surgical pocket therapy, periodontal regeneration, mucogingival therapy, implant therapy, and pathogenesis.

Recommendations in endodontology

Curriculum Guidelines for Endodontics have been developed by the Section of Endodontics of the American Association of Dental Schools (AADS 1993). These were first developed in 1981, then revised twice, and finally published in the *Journal of Dental Education* in 1993. These guidelines include definitions of endodontic treatment and determine what dental graduates must understand and how much preclinical and clinical experience allows one to become competent in performing root canal treatment. Later, the European Society of Endodontology (ESE 1994) offered international, detailed treatment guidelines developed in co-operation with the British Endodontic Society. This document addresses the appropriateness of each treatment modality and the quality or level of treatment rendered, intending to represent current good practise. Similarly, in the USA, the American Association of Endodontists (AAE 2003) published Guidelines for Endodontic Diagnosis by presenting three endodontic cases. These guidelines introduced essential steps in endodontic diagnosis-making.

Recommendations in oral implantology

The first Consensus Development Conference on Dental Implants (CDCDI 1988) by the National Institute of Dental Research in conjunction with NIH in 1978 made a statement concerning the risks and benefits of dental implants. The second conference in 1988 determined the indications and contraindications for various types of dental implants, and proposed the establishment of a National Dental Implant Registry with the objective of the collection of data and documentation of implant therapy conducted in the United States (CDCDI 1988). In the next consensus panel, experts in oral implantology evaluated the literature reviews and question sets and carefully made their responses to follow an evidence-based format, creating Consensus Report Implant Therapy I and II (CRIT I, CRIT II) (1996). CRIT I deals with implant failure, anatomical considerations in implant treatment, soft and hard tissue-implant interference, endpoint of treating a failed implant, and indications and contraindications for implant therapy; whereas CRIT II includes information about the use of radiographs, anatomical considerations, effect of diagnostics, genetic factors, and evidence regarding the sinus elevation procedure.

Methods in studying treatment decisions

Several research methods have been exploited in studying dentists' treatment decisions. In drawing conclusions about variation in dentists' treatment decisions, it is essential to consider 1) how these variations have been measured, 2) where and 3) what kind of dentist population was studied, 4) what evidence exists regarding the effectiveness of interventions, and 5) what factors are associated with the variation.

Radiographic methods

Assessment of dentists' treatment decisions has been aided by radiographic evaluation concerning the decision whether or not to place an approximal filling (Kay and Knill-Jones 1992, Kay and Locker 1996, Lewis et al. 1996) and for diagnosis of periapical tissues to decide on endodontic therapy (Lambrianidis 1985, Pagonis et al. 2000). However, radiological evaluation alone is not completely reliable in evaluation of the condition of periapical tissues and the quality of root canal fillings (Reit and Hollender 1983).

Variation in endodontic re-treatment decisions has been investigated by means of a combination of patient scenarios and radiographic information (Reit and Kvist 1998). That study offers a wider scope to measure inter-individual variation in treatment decisions by the Visual Analogue Scale and the Standard Gamble methods. Intra- and inter-individual variation in treatment decisions can be regarded as the result of a choice of different cut-off points on the continuum for prescribing re-treatment.

Clinical methods

In restorative treatment, decision-making has been investigated by examination of patients (Rytömaa et al. 1979, Bader and Shugars 1993, Bader et al. 1994) and of extracted teeth (Merrett and Elderton 1984, Maupome 2000, Owens 2000). The latter method excludes many of the usual clinical variables and probably results in greater agreement among dentists than is achieved in cases with actual patients (Merrett and Elderton 1984).

Patients have also been used in studies of treatment decisions in periodontology (Persson and Svendsen 1990, Müller et al. 1995, Loesche et al. 1997, Svardström and Wennström 2000) and in oral implantology (Andersson et al. 1995). Recording of clinical signs of inflammation, together with measurement of probing depth is considered an essential element in decision-making (Claffey 1991). Studying dentists' selection of patients for implant therapy is done by a combined method in which data from referral, case history, and clinical examination are all taken into account in the treatment decision (Andersson et al. 1995).

Survey methods

An unstructured qualitative interview as a survey method has been used by Kay and Blinkhorn (1996) to identify issues which may contribute to dentists' preferences for restorative treatment decisions. The authors emphasize the success of their investigation in identifying issues salient to restorative treatment decisions. Use of an interview is, however, limited among dental surveys.

Questionnaire studies have commonly been used in studying dental decision-making. In earlier studies in Finland, questionnaires have been applied to assess psychic and social factors in dentistry (Siirilä 1966) and to assess dentists' concepts of prosthetic treatment alternatives (Rantanen 1976). In restorative dentistry, caries assessment and treatment decisions have been evaluated by illustrating various stages of approximal and occlusal caries with schematic drawings and the clinical appearance of the teeth by photographs (Mejare et al. 1999). The authors conclude that their method does not necessarily always correspond to what actual dentists would do in practice, but their results may be applicable to assessment of dentists' treatment philosophies usual for the patient age-group studied.

In periodontology, dentists' opinions regarding factors influencing their diagnoses and the management of periodontal disease have been evaluated by use of a combination of a questionnaire for dentists and official statistics on dental care (Chestnutt and Kinane 1997). Their study was conducted in two stages: in the first stage, official data were analysed to provide information on the features of non-surgical periodontal therapy. The second stage employed a postal questionnaire inquiring about such issues as the dentists' confidence in their ability to diagnose and treat periodontal diseases, circumstances influencing their decision to probe for pockets, and factors influencing their treatment of periodontal diseases. Their good response rate (75%), together with the multiple data, offers a wide perspective on factors influencing diagnosis and management of periodontal diseases.

In endodontology, problems related to re-treatment have been explored by describing and illustrating cases of endodontically treated teeth with schematic drawings and radiographs, each case being supplied with alternative treatment options (Hülsmann 1994, Kvist et al. 1994, Aryanpour et al. 2000). In addition, dentists have been asked to assess the difficulty of making their re-treatment decisions and the technical complexity of such cases (Aryanpour et al. 2000). The authors conceded that their study method was inadequate in identifying all of the causes of decision variation, but it provides evidence regarding the rates of consensus and disagreement in treatment decisions.

In prosthodontics, Rantanen (1976) collected data by questionnaire from 1757 Finnish dentists concerning time spent on prosthetic treatment and the features and evaluation of the necessity of treatment. He suggested that although each survey regarding human

behaviour contains some bias, differences between dentist groups seemed quite reliable. Further, a questionnaire has been used in evaluating fixed partial dentures versus removable dentures, the dentists' being asked to mark the relative importance of the 14 item listed (Kronström et al. 1999a). The authors discussed the fact that although personality traits are difficult to capture in a questionnaire study, and the patient properties were not particularly specified, the results showed a striking resemblance to those from the pilot study, supporting the study reproducibility. Further, one investigation of treatment options for replacing a missing tooth presented descriptions of clinical situations (Söderfeldt et al. 1996), inquiring how much, from unimportant to absolutely decisively, the factors presented, e.g., patient's age and general health and dentist experience, should influence a prosthetic treatment decision. According to the authors, such questionnaire studies have been considered feasible and useful in prosthodontic decision-making.

In implantology, failure rates, common causes of failures, their early detection and definition, and the treatment of the failed implants have been studied by questionnaire (Tinsley et al. 1999). The authors discussed the fact that the study topic was a wide one to cover in one questionnaire, and some of the questions required considerable time to complete. Although the response rate was low (33%), the study included over 5000 implants, and the authors considered it appropriate to analyse the responses received. Further, Butterworth et al. (2001) used a questionnaire when assessing working activity of restorative dentistry consultants and contraindications in patient selection for implant treatment. They discussed that the good response rate (75%) indicates the importance attached to that form of treatment by the consultants involved.

AIMS OF THE STUDY

The general aim of the present study was to investigate theoretical knowledge for treatment decisions by dentists in Finland.

More specific aims were:

1. To determine variation in Finnish dentists' theoretical knowledge for treatment decisions in restorative dentistry, periodontology, endodontology, and in oral implantology among public dentists, private dentists, and dental teachers
2. To evaluate whether dentists' theoretical knowledge for treatment decisions is in accordance with international treatment recommendations and guidelines which exist in periodontology, endodontology, and implantology
3. To evaluate the impact of dentists' characteristics on their theoretical knowledge for optimal treatment decisions

HYPOTHESES

Finnish dentists' theoretical knowledge for treatment decisions:

1. does not vary by working sector
2. does not vary by work-related and personal characteristics
3. is in accordance with existing international treatment recommendations and guidelines in periodontology, endodontology, and in oral implantology

SUBJECTS AND METHODS

Data collection

The target dentists in the present study were selected by stratified randomisation among members of the Finnish Dental Association. The sample covers general practitioners (GPs; n=400) aged 30 to 49 years. A total of eight clusters were formed according to main employment (public or private sector), gender, and age (30-39 or 40-49 years). An equal number of GPs were randomly selected from each cluster (Table 1).

Table 1. Number of subjects enrolled in the eight clusters by age-group.

Ages	Male		Female		Total
	30-39	40-49	30-39	40-49	
Public dentists	50	50	50	50	200
Private dentists	50	50	50	50	200
Total	100	100	100	100	400

In addition, the study included all full-time dental teachers (DTs) (n=47), with no age limitations, representing clinical disciplines other than surgery and orthodontics in all dental schools in Finland (Universities of Helsinki 18, Oulu 22, and Turku 7).

The questionnaire was pre-tested by 10 dentists primarily engaged in clinical practice, and was revised accordingly. Data collection began in February 1999. The questionnaire, including a cover letter undersigned by both the supervisors and the researcher, was remailed twice: after 3 and after 6 weeks. The questionnaire inquired about dentists' work-related and personal background, including

1. respondent's gender (male/female)
2. age (25-29 years, 30-39 years, 40-49 years, 50-65 years)
3. university of graduation (University of Helsinki, Oulu, Kuopio, Turku, or elsewhere)
4. professional working experience (0-4 years, 5-9 years, 10 years or more)
5. main employment (public or private sector)
6. province of practice (southern, eastern, or western Finland, Oulu or Lapland regions)
7. location of practice (rural or urban)
8. type of practice (solo or group practice)
9. work arrangement (working alone or with a dental assistant)
10. specialised licence (clinical discipline, other, or no specialised licence)
11. number of continuing education days in the preceding year (none, 1-3 days, 4-5 days, 6-10 days, 10 or over)
12. proportion of adult patients (0-25%, 26-50%, 51-75%, over 75% of working time, no patients of this age)

As regards theoretical knowledge for treatment decisions, the dentists were to select one alternative from among the 2 to 8 options presented in the questionnaire for each clinical case related to four common disciplines of dentistry: restorative dentistry (R-Cases 1 to 3), periodontology (P-Cases 1 to 7), endodontology (E-Cases 1 to 4), and oral implantology (I-Cases 1 to 10). All cases were described in detail to allow respondents to make an optimal treatment or re-treatment decision, assuming no economic constraints for each case. Clinical cases are presented in "Description of cases" (pages 32-37). The original Finnish version of the questionnaire is presented in Appendix 1, and the English translation in Appendix 2. (Note, I-Case A, I-Case-B, and Patients' treatment compliance with recommended treatment in dental care are not analysed in this thesis).

Response rate and respondents background

The total number of questionnaires mailed was 447, of which 346 (77%) were returned. The overall number of responding GPs was 311 (78%), including 165 public dentists (83%) and 146 private dentists (73%). Response rate was 88% for female and 68% for male dentists, 82% for those aged 30 to 39, and 74% for those aged 40 to 49 years. Regarding these factors, no difference was found in comparison with the original clusters. Dentists' work-related and personal background variables for the public and private dentists are shown in Table 2. The number of DTs responding was 35 (74%). The majority were females (63%), 74% had professional working experience of 10 years or more, 73% worked mainly with adult patients (over 75% of patients), and 74% held a specialised licence.

Table 2. Dentists' characteristics as work-related and personal background variables for the public and private dentists studied.

Background variables	Public dentist (n=165)		Private dentists (n=146)		p-value
	n	%	n	%	
Gender:					
Male	69	42	66	45	0.548
Female	96	58	80	55	
Professional working experience:					
Fewer than 10 yrs	41	25	55	38	0.015
10 yrs or more	124	75	91	62	
Proportion of adult patients:					
0-50%	73	44	1	1	0.000
51-75%	73	44	12	8	
Over 75%	17	10	133	91	
Missing data	2				
Continuing education in the preceding year:					
None	7	4	4	3	0.428
1 to 3 days	66	40	48	33	
4 to 5 days	54	33	50	34	
More than 5 days	38	23	44	30	
Location of practice:					
Rural	74	45	13	9	0.000
Urban	90	55	133	91	
Missing data	1				
Type of practice:					
Solo	23	14	54	37	0.000
Group	142	86	92	63	
Working with dental assistant:					
Yes	162	98	123	84	0.000
No	2	1	22	15	
Missing data	1		1		
University of graduation:					
Helsinki	41	25	55	38	0.037
Turku	54	32	51	35	
Oulu	34	21	17	12	
Kuopio	29	18	19	13	
Abroad	7	4	3	2	
Missing data			1		
Specialised licence:					
Yes	13	8	8	5	0.405
No	147	89	133	91	
Missing data	5		5		

Statistical evaluation by chi-square test, differences between public and private sector.

Description of cases

Restorative dentistry

R-Case 1: A 56-year-old healthy woman had lost a supragingival, direct composite crown in tooth 24 one week previously. She told that endodontic treatment had been performed about 2 years earlier, with no symptoms occurring since then. No radiograph was enclosed, but information related to it was given: an adequate root canal filling with a healthy periapical region. Occlusion was described as normal, the fillings in the related teeth being as follows: tooth 23, amalgam on distal and palatal surfaces; tooth 25, amalgam on occlusal, mesial, and buccal surfaces; amalgam fillings dominated in other teeth as well. The patient asked for aesthetic and long-lasting treatment. The respondents were asked to choose the optimal treatment, assuming no economic constraints, from these alternatives: composite crown (direct or indirect), full crown, extraction of the root followed by bridge construction, or the dentist's free-format suggestion.

In the analyses, the treatment alternatives for R-Case 1 were reclassified according to materials and techniques into two categories: 1) composite crown (direct) and 2) indirect restoration (composite crown, full crown, or extraction followed by bridge construction).

R-Case 2: The patient was the same as in R-Case 1. In this case, she had an amalgam filling in tooth 26. The shaded areas (Figure 5) illustrate the four sizes of failed restorations. The respondents were asked to choose for each subcase the optimal treatment, assuming no economic constraints, from these alternatives: composite (direct and indirect), amalgam, ceramic inlay/onlay, gold cast inlay/onlay, full crown, or extraction followed by bridge.

R-Case 3: A 45-year-old healthy man told about all of his first molars having been extracted at 12 years of age and all third molars at about 20. His DMFT index was 24, and there was a 5 mm diastema at the site of the tooth 46. Secondary caries had widely destroyed the neighbouring second molar (47) which, however, was vital and asymptomatic, with a healthy periodontium and no need for endodontic therapy. The patient asked for a long-lasting treatment. The respondents were asked to choose the optimal treatment, assuming no economic constraints, from these alternatives: composite (direct and indirect), amalgam, ceramic inlay/onlay, gold cast inlay/onlay, full crown, extraction, or this dentist's free-format suggestion.

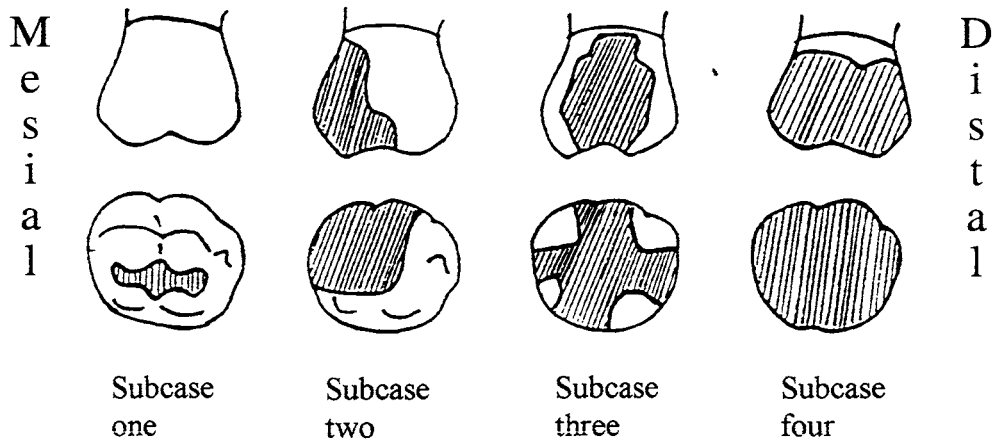


Figure 5. Buccal and occlusal diagrams of tooth 26. Shaded areas illustrate the size of the lost filling (from Study I).

For R-Case 2 and R-Case 3, reclassification included three categories: 1) amalgam restoration, 2) direct composite restoration, 3) indirect restoration (indirect composite restoration, cast gold inlay/onlay, ceramic inlay/onlay, full crown).

For R-Case 1, three respondents were excluded because they did not complete this part, for R-Case 2, subcases one to four, the number of missing answers ranged from one to two, and for R-Case 3, seven respondents were excluded. Further, for R-Case 3, 40 respondents gave a free-format suggestion indicating "bridge for teeth 47 - 45". These answers were reclassified as indirect restoration.

Recommendations: In restorative dentistry, no exact international recommendations and guidelines concerning treatment, re-treatment techniques, and material selection exist.

Periodontology

P-Case 1: A 32-year-old healthy man had been on dentist's recall for over 10 years. Three years earlier, he had had endodontic therapy for tooth 22 due to caries. Six months earlier, a clinical examination revealed an 8-mm periodontal pocket on the distal surface, then treated by scaling. Now the pocket was bleeding and was still 8 mm deep, but with no suppuration. The tooth was asymptomatic, and no other deepened pockets were found

elsewhere. The technical quality of the guttapercha root canal filling was good, and no changes were evident in the periodontal ligament space around the apex. The respondents were asked to choose the optimal treatment from the following alternatives:

1. More effective oral hygiene instruction, and a re-assessment after 3 months
2. More effective oral hygiene instruction, and a re-assessment after 6 months
3. Rescaling within one month
4. Flap-operation within one month performed by the respondent
5. Flap-operation within one month; referral to a periodontist
6. Free-format suggestion by the respondent

For the analyses of P-Case 1, the first two alternatives were combined.

P-Cases 2-7: The patient had an obvious need for periodontal surgery (flap-operation) because of diseased and deepened periodontal pockets on teeth 24-26. The dentition was healthy and well treated. Respondents were asked to choose whether or not each of the six potential contraindications for periodontal surgery would influence their treatment decisions:

P-Case 2. Despite clear oral hygiene instruction and attempts to comply, the patient has not achieved sufficient oral hygiene

P-Case 3. The patient had a cardiac infarction one year ago

P-Case 4. The patient had surgery for an endoprosthesis in his/her right knee 2 years ago because of rheumatic disease

P-Case 5. The patient has diabetes mellitus and receives insulin treatment. Despite several daily injections, the blood glucose level varies widely

P-Case 6. The patient smokes about 20 cigarettes daily

P-Case 7. The patient is over 70 years of age and in good health

For analyses of P-Cases 2 to 7, each of the respondent's treatment decisions in agreement with recommendations were scored as 1, then summed to describe his/her level of knowledge of potential contraindications.

For P-Case 1, 16 free-format suggestions were received. Because these could not be classified into any of the five categories, they were excluded from analysis. In P-Cases 2 to 7, one to seven respondents were excluded because they did not complete this patient-characteristics section.

Recommendations: For P-Case 1, the recommendations of the *Textbook of Clinical Periodontology*, (TCP) (Lindhe 1990), CRWWP (1996), and *Clinical Periodontology and Implant Dentistry*, (CPID) (Lindhe 1998) suggest surgical treatment. For P-Cases 2 to 7, according to the recommendations (Lindhe 1990, CRWWP 1996, Lindhe 1998), inadequate oral hygiene (P-Case 2) and poorly controlled diabetes (P-Case 5) are absolute contraindications, the decision being to avoid periodontal surgery. The other four conditions (P-Cases 3, 4, 6, 7) may worsen prognosis after treatment and are relative contraindications.

Endodontology

E-Case 1: A 45-year-old healthy man, a new patient of the dentist, told of endodontic treatment in tooth 25 about 5 years previously. On examination, this tooth proved asymptomatic and in normal occlusion. A radiograph (Figure 6) with the following statement was attached: underfilled root canal and crown with post, widened periodontal ligament space around the apex, but no periapical radiolucency.



Figure 6. Radiograph of tooth 25.

E-Cases 2 to 4: A 35-year-old healthy woman had been on the dentist's recall for over 10 years. Endodontic treatment due to pulp exposure had been performed in tooth 22 about 5 years previously. The quality of the guttapercha root canal filling was good, the root canal was straight, and there was no post. Now the patient described brief periods (2-5 minutes) of pain associated with the tooth during the past 3 weeks. Clinical examination revealed only slight pain after vertical percussion; occlusion was normal. No radiograph was provided, but radiographic statements for three scenarios (E-Cases 2 to 4) of different radiographic findings were available: E-Case 2 with a widened periodontal ligament space around the apex, but no radiolucency, E-Case 3 with a radiolucency of 2 mm, and E-Case 4 with a radiolucency about 7 mm in diameter around the apex.

For each of the E-Cases, the respondent was asked to choose the optimal treatment from among eight alternatives:

1. No therapy indicated, re-assessment after 3 months
2. No therapy indicated, re-assessment after 6 months
3. No therapy indicated, re-assessment after one year
4. Endodontic therapy needed within one month and performed by the respondent
5. Endodontic therapy needed within one month and performed by an endodontist
6. Apical surgery on the tooth within one month performed by the respondent
7. Apical surgery on the tooth within one month performed by a specialist
8. Any other suggestion by the respondent

In the analyses of each E-Case, treatment options 1-3 were reclassified as "re-assessment" and 4 to 7 as "active treatment".

For E-Case 1, two respondents, and in E-Cases 2 to 4, one to three respondents were excluded because of failure to complete this part.

Recommendations: Interpretation of the recommendations of the ESE report (ESE 1994) would suggest re-treatment for E-Case 1 only when the coronal restoration requires replacement or the coronal dental tissue needs to be bleached, the optimal treatment decision's being to assess the tooth. Further, according to the ESE report, an inadequate root canal filling with radiological findings or symptoms or both are indications for root canal re-treatment, which should thus be seen as the optimal treatment for E-Cases 2 to 4.

Oral implantology

I-Cases 1 to 10: The patient had lost his/her tooth 11. The amount of bone was sufficient for implant therapy, and occlusion was normal. The respondents were asked to state whether or not they would recommend implant therapy in each situation of the 10 cases. Relevant patient variables were described to guarantee that implant therapy could be considered as the optimal treatment.

I-Case 1. Despite clear oral hygiene instructions and attempts to comply, the patient has not achieved sufficient oral hygiene

I-Case 2. The patient has several untreated caries lesions in molars and premolars

I-Case 3. The patient has several deep (6 mm or more in depth) periodontal pockets in molars and premolars

I-Case 4. The patient has diabetes mellitus and is receiving insulin treatment. Despite several daily injections, the blood glucose level varies widely

I-Case 5. The patient had a cardiac infarction one year ago

I-Case 6. The patient had surgery for an endoprosthesis in his/her right knee 2 years ago because of rheumatoid arthritis

I-Case 7. The patient is over 70 years of age and in good health

I-Case 8. The patient smokes about 20 cigarettes daily

I-Case 9. The patient is outside the recall system

I-Case 10. The patient is asking for an aesthetic treatment

Here, from case to case, the number of missing answers ranged from 2 to 14. According to type of potential contraindication or patient characteristics, the 10 cases were classified into three categories: Oral factors: I-Cases 1 to 3; Medical factors: I-Cases 4 to 6; Personal factors: I-Cases 7 to 10.

Recommendations: Inadequate oral hygiene and poorly controlled diabetes were considered absolute contraindications by the CDCDI (1988) and Lekholm (1998), but by the CRIT I (1996) as relative contraindications. Due to this discrepancy between recommendations, optimal treatment in these two cases was considered to be conservative: to avoid implant surgery. The other eight were only relative contraindications or were patient characteristics, so implant surgery was considered the optimal treatment decision.

Treatment Decision Competency Score

A Treatment Decision Competence Score (TDCS) was developed to describe a dentist's overall competency in making optimal treatment decisions. The existing international treatment recommendations and guidelines for periodontology, endodontology, and oral implantology were applied to the cases presented in the present study. Each of the respondent's treatment decisions in agreement with these recommendations received one competency point. The total points from the seven periodontology cases, four endodontic cases, and ten cases related to oral implantology were then weighted so that each discipline represented one-third of the TDCS, its theoretical maximum's being 21 (Table 3).

Table 3. TDCS as a weighted sum of competence points.

	points	weight	TDCS
Periodontal cases:	0-7	7/7	0-7
Endodontic cases:	0-4	7/4	0-7
Cases related to oral implantology:	0-10	7/10	0-7
Theoretical maximum:	21		21

Statistical methods

Comparisons between group means were performed by Student's t-test and ANOVA; significance of differences in frequencies between dentist groups was tested by means of the chi-square test. A difference was considered statistically significant at the level of $p=0.05$. Estimates for public- and private-sector dentists were adjusted by weighting gender-based figures with the real gender distribution within each sector. Similarly, estimates for all GPs were adjusted by weighting the sector-based figures with the actual distribution of dentists by sector.

Associations between variables were demonstrated by the correlation coefficients, and their statistical significance was evaluated by Fisher's transformation (Rao 1965). Logistic regression models were fitted to the data to evaluate the impact of dentists' characteristics on their treatment decisions. The corresponding odds ratios and their 95% confidence intervals were calculated (McCullagh and Nelder 1983). Finally, linear regression models were used to evaluate the impact of dentists' characteristics on their decisions as regards implant therapy separately for three categories of potential contraindications or patient characteristics.

RESULTS

Theoretical knowledge for treatment decisions by sector and by discipline

Theoretical knowledge for treatment decisions in restorative dentistry (I)

For R-Case 1, all DTs and the majority of GPs chose the indirect restoration as their treatment decision. A direct composite restoration was preferred more frequently by public than by private dentists (Table 4). Clear differences existed in theoretical knowledge for treatment decisions between the three dentist groups as regards medium-sized and large restorations: in R-Case 2, for subcases two to four, private dentists and DTs frequently preferred more indirect restorations than did public dentists. For R-Case 3, the majority of all dentists chose indirect restoration, with no difference between dentist groups.

Theoretical knowledge for treatment decisions in periodontology (II)

For P-Case 1 (8-mm pocket in tooth 22), almost all the DTs (94%) and the majority of private (70%) and public (65%) dentists chose surgery as their treatment decision, the difference between DTs and GPs being statistically significant ($p < 0.001$). Of contraindications presented in P-Cases 2 to 7, (poor oral hygiene, cardiac infarction, endoprosthesis, poorly controlled diabetes, smoker, age over 70) the only difference between dentist groups appeared for the smoking patient, with private dentists recommending surgery more frequently (67%) than did the DTs (63%) and public dentists (51%) ($p = 0.010$). For patients with a previous cardiac infarction or endoprosthesis, or for patients over 70 years, 87% or more of all dentists recommended periodontal surgery, with no difference between groups. For patients with poorly controlled diabetes, 67% of private dentists and DTs and 57% of public dentists recommended surgery ($p = 0.206$).

Table 4. Theoretical knowledge of restorative treatment decisions in R-Cases 1 to 3 (See Fig. 5, p. 33) by dentist group.

R-Cases and theoretical knowledge for treatment decisions	Public sector n=165 % ¹	Private sector n=146 % ¹	Dental teachers n=35 %	p-value ²
R-Case 1 Direct composite crown Indirect restoration	19 82 ^a	6 94	0 100	0.000
R-Case 2 Subcase one Amalgam filling Direct composite restoration Indirect restoration	5 92 3	5 92 3	9 83 8	0.551
Subcase two Amalgam filling Direct composite restoration Indirect restoration	8 54 38 ^a	6 38 56	9 20 71	0.000
Subcase three Amalgam filling Direct composite restoration Indirect restoration	9 36 55 ^a	7 19 74	6 6 88	0.000
Subcase four Amalgam filling Direct composite restoration Indirect restoration	5 8 87 ^a	2 3 95	0 0 100	0.025
R-Case 3 Amalgam filling Direct composite restoration Indirect restoration	8 11 81	5 9 86	3 0 97	0.127

R-Case 1: loss of supragingival direct composite crown, tooth 24. R-Case 2, subcase one: loss of amalgam filling on occlusal surface, tooth 26; subcase two: loss of amalgam filling on occlusal, mesial, and buccal surfaces, tooth 26; subcase three: loss of amalgam filling on occlusal, mesial, buccal, palatal, and distal surfaces, tooth 26; subcase four: loss of amalgam filling up to gingival margin, tooth 26; R-Case 3: large secondary caries, tooth 47.

¹ Gender-adjusted.

² Statistical evaluation by chi-square test for differences between the three dentist groups.

^a Statistical evaluation by chi-square test for differences between public and private sector: p<0.05, all others non-significant.

Theoretical knowledge for treatment decisions regarding endodontically treated teeth (III)

For E-Case 1 (asymptomatic tooth 25, underfilled root canal, widened periodontal ligament space, no radiolucency), the majority (94%) in all groups chose re-assessment of the tooth. Re-treatment or periapical surgery was chosen by 6%, by private dentists more frequently than by public dentists (11% vs. 3%, $p<0.05$). For E-Case 2 (2-5 minutes pain sensations during 3 weeks, adequate root filling, and widened periodontal ligament space), active treatment was chosen by 31% of the DTs, 22% of the public dentists, and by 22% of the private dentists. For E-Case 3 (2-5 minutes pain during 3 weeks, adequate root filling, radiolucency 2 mm), the majority of all dentists chose active treatment, and for E-Case 4 (2-5 minutes pain during 3 weeks, adequate root filling, radiolucency 7 mm), all dentists chose active treatment of the tooth. For E-Cases 2 to 4, no difference in theoretical knowledge for treatment decisions appeared between groups.

Theoretical knowledge for treatment decisions in oral implantology (IV)

Theoretical knowledge for treatment decisions as regards recommending implant therapy for 10 cases with various contraindications and patient characteristics differed by group. Private dentists recommended implant therapy on average for 57% of all cases, DTs for 50%, and public dentists for 48% ($p<0.01$). Case by case, private dentists recommended implant therapy more frequently than did public dentists.

For I-Case 1 (inadequate oral hygiene), fewer than 15% of all dentists and for I-Case 3 (deep periodontal pockets), fewer than 19% recommended implant therapy. For I-Case 2 (patient with untreated caries lesions), implant therapy was recommended by 45% of private dentists, 25% of public dentists, and 32% of DTs ($p=0.002$). Implant therapy was recommended by the majority of all dentists (70%-94%) for I-Case 5 (patient with previous cardiac infarction); for I-Case 7 (patient over age 70), by DTs more frequently than by private and public dentists. Conversely, private dentists (48%) and public dentists (44%) recommended implant therapy more frequently for I-Case 8 (the smoking patient) than did DTs (15%) ($p=0.002$).

Agreement with international recommendations and guidelines (II-IV)

In theoretical knowledge for periodontal treatment decisions, 70% of dentists agreed with the international recommendations in P-Case 1. In P-Cases 2 to 7, 8% of the respondents chose the treatment alternatives for all six contraindications in accordance with existing

recommendations. For contraindications related to cardiac infarction, endoprosthesis, and patient age (over 70 years), 87 to 97% of all dentists agreed with international recommendations (Table 5). Contrary to the recommendations, surgery for the poorly controlled diabetes patient was chosen by 57% to 67% of respondents, by private dentists and DTs more frequently than by public dentists.

Table 5. Respondents (%) in agreement with treatment recommendations in periodontology.

P-Cases	Recommendation	Public sector n=165 % ¹	Private sector n=146 % ¹	Dental teachers n=35 %	General practitioners n=311 % ²	p-value ³
P-Case 1	S	65	70	94	68 ^b	0.003
P-Case 2	N	79	74	77	77	0.544
P-Case 3	S	87	90	97	88	0.241
P-Case 4	S	92	94	97	93	0.680
P-Case 5	N	43	33	33	39	0.206
P-Case 6	S	51 ^a	67	63	58	0.010
P-Case 7	S	90	92	97	91	0.405

P-Case 1: 8-mm pocket in tooth 22; P-Case 2: inadequate oral hygiene; P-Case 3: patient with previous cardiac infarction; P-Case 4: rheumatic patient with endoprosthesis; P-Case 5: patient with poorly controlled diabetes; P-Case 6: smoker; P-Case 7: patient over 70.
S = surgery, N = no surgery.

¹ Gender-adjusted.

² Gender- and sector-adjusted.

³ Statistical evaluation by chi-square test for differences between the three dentist groups.

^a Statistical evaluation by chi-square test for differences between public and private sector:
p<0.01, all others non-significant.

^b Statistical evaluation by chi-square test for differences between general practitioners and dental teachers;
p<0.001, all others non-significant.

For endodontic treatment, the majority of dentists agreed with international recommendations in three of four cases (Table 6). In E-Case 2, the majority of dentists (76%) chose against existing recommendations, with no difference between the groups.

For theoretical knowledge for treatment decisions related to implant therapy, in most cases the majority of all dentists agreed with international recommendations (Table 7). The two contraindicated cases were well recognised; for the patient with poorly controlled diabetes 88%, and for the patient with inadequate oral hygiene 85% of dentists agreed with the recommendations. The DTs were farthest from the recommended practice for the smoking patient (15% agreed) and the patient with deep periodontal pockets (9% agreed).

Table 6. Respondents (%) in agreement with treatment recommendations regarding endodontically treated teeth.

E-Cases	Recommendation	Public sector n=165 % ¹	Private sector n=146 % ¹	Dental teachers n=35 %	General practitioners n=311 % ²	p-value ³
E-Case 1	R	97 ^a	89	94	94	0.038
E-Case 2	A	22	22	31	22	0.445
E-Case 3	A	80	80	74	80	0.697
E-Case 4	A	100	100	100	100	1.000

E-Case 1: asymptomatic tooth 25, an underfilled root canal, widened periodontal ligament space, no radiolucency; E-Case 2: 2-5 min pain during 3 weeks, adequate root canal filling, widened periodontal ligament space; E-Case 3: 2-5 min pain during 3 weeks, adequate root canal filling, radiolucency of 2 mm; E-Case 4: 2-5min pain during 3 weeks, adequate root canal filling, radiolucency of 7 mm.

R= re-assessment, A = active treatment.

¹ Gender-adjusted.

² Gender- and sector-adjusted.

³ Statistical evaluation by chi-square test for differences between the three dentist groups.

^a Statistical evaluation by chi-square test for differences between public and private sector: p<0.05, all others non-significant.

Role of dentists' characteristics in decision-making

Results by discipline

In restorative dentistry, a decision in favour of indirect restoration for the two failed medium-sized fillings was associated with dentists working in the private sector (OR=2.3 and 2.4; p=0.001), and with a greater number of CE days (OR=1.4; p=0.009). For details, see Study I.

In periodontology, a preference for periodontal surgery was associated with greater number of CE days (OR=1.5; p=0.005). Among public dentists, self-performed surgery was preferred more frequently by male than female dentists (44% vs. 21%, p=0.001), and by younger than older dentists (38% vs. 22%, p=0.014). For details, see Study II.

In endodontology, a decision in favour of active therapy was associated with a dentist's higher share of adult patients (OR=2.8; p=0.01), and in E-Case 2 with dentists' younger age (OR=0.6; p=0.05). For details, see Study III.

Table 7. Respondents (%) in agreement with treatment recommendations in implantology.

I-Cases	Recommendation	Public sector n=165 % ¹	Private sector n=146 % ¹	Dental teachers n=35 %	General practitioners n=311 % ²	p-value ³
Oral factors:						
I-Case 1	N	91 ^a	80	79	86	0.040
I-Case 2	I	25 ^a	45	32	34	0.002
I-Case 3	I	15 ^a	26	9	20	0.011
Medical factors:						
I-Case 4	N	89	85	85	88	0.384
I-Case 5	I	70	84	94	76 ^b	0.003
I-Case 6	I	65	76	77	70	0.181
Personal factors:						
I-Case 7	I	75	88	94	81	0.012
I-Case 8	I	44	48	15	46 ^b	0.002
I-Case 9	I	73	76	73	75	0.813
I-Case 10	I	96	96	94	96	0.751

Oral factors: I-Case 1: inadequate oral hygiene; I-Case 2: untreated caries lesions; I-Case 3: deep periodontal pockets. Medical factors: I-Case 4: patient with poorly controlled diabetes; I-Case 5: patient with previous cardiac infarction; I-Case 6: rheumatic patient with endoprosthesis. Personal factors: I-Case 7: patient is over 70; I-Case 8: smoker; I-Case 9: patient outside the recall system; I-Case 10: patient ask for an aesthetic treatment. I = implant surgery, N = no implant surgery.

¹ Gender-adjusted.

² Gender- and sector-adjusted.

³ Statistical evaluation by chi-square test for differences between the three dentist groups.

^a Statistical evaluation by chi-square test for differences between public and private sector: p<0.05, all others non-significant.

^b Statistical evaluation by chi-square test for differences between general practitioners and dental teachers; p<0.05, all others non-significant.

In implantology, the male dentists recommended implant therapy more frequently for the patients with a previous infarction (87% vs. 71%, p=0.001), with endoprosthesis (84% vs. 64%, p=0.000), and of age over 70 (89% vs. 78%, p=0.006). Variation in theoretical knowledge for treatment decisions appeared for number of CE days: dentists with a greater number of days of CE recommended implant therapy more frequently for patients with oral and medical contraindications (p<0.05) but less frequently for cases with personal factors (p<0.01). For a smoker, older dentists preferred implant therapy more frequently than did the younger dentists (51% vs. 40%, p=0.049). For details, see Study IV.

Intercorrelations of dentists' competencies within the three disciplines (periodontology, endodontology, and implantology) are shown in Table 8. For all dentists, good competency in periodontology was related to good competencies in endodontology (r=0.27) and in implantology (r=0.25). All correlations between competencies in endodontology and implantology were weak.

Table 8. Associations by gender and sector regarding optimal treatment decisions in periodontology with those in endodontology and implantology, by use of correlation coefficients.

Association of optimal treatment decisions in periodontology with those in:	By gender			By sector		
	Male r	Female r	p ¹	Public r	Private r	p ²
Endodontology	0.32***	0.23**	0.20	0.14*	0.38***	0.01
Implantology	0.11	0.32***	0.03	0.18*	0.37***	0.04

p-values: ¹ for differences by gender; ² for differences by sector:

*** p<0.001; ** p<0.01; * p<0.05; when testing r≠0.

Overall competency

Regarding dentists' overall competency in the three disciplines, described as a weighted score for optimal treatment decisions (TDCS) with a theoretical maximum of 21, half the dentists achieved a score of 15.1 or higher. The upper limit for the lowest quartile was as high as 13.7, and the upper limit for the highest quartile was 19.3 (Figure 7).

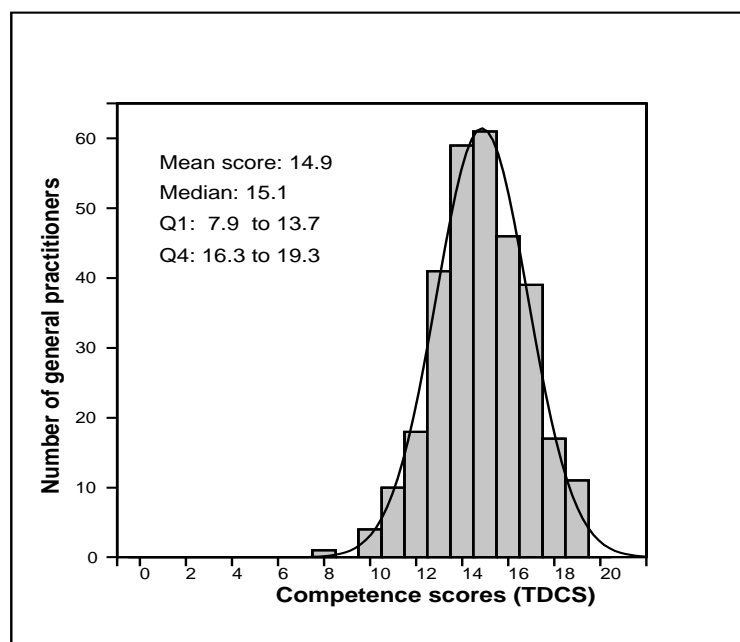


Figure 7. A histogram of the competence scores of the GPs, fitted with the theoretical normal distribution.

TDCS distributions as box and whisker diagrams by gender and working sector are in Figure 8. Median TDCS was greatest for male dentists in the private sector (16.2), followed by DTs (15.5), and female dentists in the public sector (15.1). Mean TDCS was 14.9 (SD 1.9), with an overall difference between all of these five subgroups ($p=0.004$), but with no difference between DTs and any of the GPs subgroups. Mean TDCS for male dentists in the private sector was greater than that for female dentists in the public ($p<0.001$) and private sector ($p<0.01$) and for male dentists in the public sector ($p<0.05$).

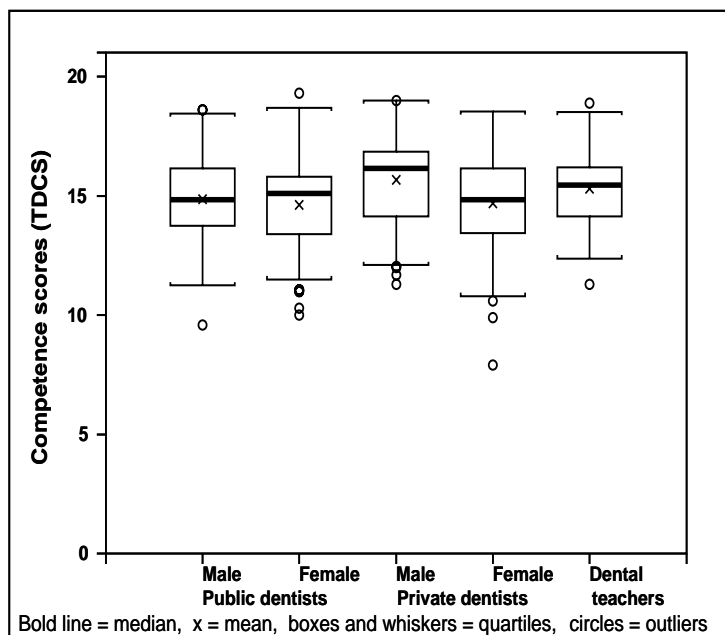


Figure 8. Distribution of competence scores in relation to dentist's gender and working sector, presented as box & whisker diagrams. (Public dentists: male $n=69$, female $n=95$. Private dentists: male $n=64$, female $n=79$. Dental teachers $n=34$).

Among the GPs, male dentists' mean TDCS was greater than the females' (15.3 vs. 14.6, $p=0.006$). The impact of CE on TDCS was weak and confusing: for female dentists more days in CE tended to result in a greater TDCS, but this was not the case for male dentists. Among those with at least 5 days of CE per year, the mean TDCS was the same for female and male dentists (15.1, SD 1.8).

Whether or not a dentist belonged to the highest quartile of the TDCS was evaluated by fitting a logistic regression model to the data, with dentists' characteristics serving as independent variables (Table 9). The model revealed the only significant factor as being gender: compared to females, male dentists' odds for belonging to the highest quartile of the TDCS was 1.9 (95% CI 1.0, 3.4), when controlling for a total of nine other dentist- and practice characteristics.

Table 9. Odds ratios for belonging to the highest quartile in treatment decision competency score, only dental general practitioners included (n=311).

Dentists' characteristics	Estimate	p-value	OR	95% CI
Gender Female Male	0.6	0.05	1.9	1.0-3.4
Age 30-39 yrs 40-49 yrs	-0.2	0.57	0.8	0.4-1.6
Working sector Public Private	0.7	0.15	2.0	0.8-5.4
Province Southern Others	0.4	0.15	1.5	0.9-2.8
Professional working experience (years)	0.1	0.73	1.1	0.6-1.9
Location of practice Rural Urban	0.4	0.33	0.33	0.7-3.3
Type of practice Solo Group	-0.1	0.70	0.9	0.4-1.8
Working With a nurse Without a nurse	0.0	0.95	1.0	0.3-2.9
Continuing education (days)	0.1	0.53	1.1	0.8-1.5
Proportion of adult patients 75% or less	0.0	0.92	1.0	0.6-1.8

OR = Odds ratio, 95% CI = 95% confidence interval, Deviance 299.5, df 28.

DISCUSSION

The present study investigated dentists' theoretical knowledge for treatment decisions in the public and private sector and by dental teachers in four common clinical disciplines: restorative treatment, periodontology, endodontology, and oral implantology. The first three were selected because they play a decisive role in dentists' daily decision-making. Implantology was included because it is a constantly growing discipline, and the possibilities for using implants are expected to increase in the future.

In total, Finnish dentists' theoretical knowledge for treatment decisions varied by working sector, thus giving no support to the first hypothesis. However, for most of the patient cases, only a small if any variation was based on dentists' work-related and personal characteristics, which supports the second hypothesis. Their theoretical knowledge for treatment decisions seems to be at an acceptable level, since the majority of dentists knew the international recommendations and guidelines; these results thus support the third hypothesis.

As to the dentists' characteristics; age, gender, number of CE days, and patient-mix each showed an association with dentists' theoretical knowledge for treatment decisions in one or another of the disciplines but not consistently in all disciplines. This may be due to each dentist's different mind-set and experience influencing treatment decisions.

The Finnish dentists' overall competency can be considered acceptable, since median TDCS was around 15 out of the theoretical maximum of 21. The TDCS was developed to describe dentists' theoretical knowledge for optimal treatment decisions in the three disciplines with existing guidelines.

Subjects and methods

Respondents and response rate

The sample was selected by stratified randomisation to cover a sufficient number of dentists in all subgroups by age, gender, and main employment. The age of the target group was restricted to 30- to 49-year-olds in order to obtain theoretical knowledge for treatment decisions of the most actively working dentists. This age-group covers

two-thirds of all dentists in the public and private sector in Finland (Vaalgamaa and Ohtonen 2000). The lower age-limit was defined to guarantee that the target dentists had already matured in their professional skills, which is assumed to take some years after graduation. Further, maintenance and development of these skills can surely be aided by active participation in CE.

Numbers of dentists in the public and private the sector have been, during this project, approximately equal in Finland. Although the patients and treatment procedures may differ by dentists' working sector, all dentists have basically the same undergraduate training experience (Public law: Decree concerning degrees in dentistry 290/1976), and it thus can be expected that all dentists have similar basic knowledge or information after graduation. The third dentist group was all full-time dental teachers, to represent the most recent knowledge related to present issues.

Recently reported response rates to questionnaires by dentists seem to range from a very low (31%) in Norway (Mjör et al. 1999) to a very high (98%) in Mongolia (Tsevenjav et al. 2003). The present study's overall response rate was for GPs, 78% and for DTs, 74%, both of which can be regarded as good for a postal survey (Chadwick et al. 1984). The relatively rare issue of treatment decisions may have aroused respondents' interest in answering and thus also have increased the response rate. In the Finnish dental profession, female dentists dominate, but to ensure sufficient data on males, numbers of female and male dentists were made equal. The response rate was lower for male than for female dentists, but still high enough (68%) to give a reliable picture of male dentists' theoretical knowledge for treatment decisions.

The response rates were high enough to give a reliable picture of theoretical knowledge for treatment decisions in each subgroup. In case the non-respondents represented different opinions from those of dentists responding, the result may still have remained valid due to the high response rates. Further, the higher response rates for public dentists, for female dentists, and for dentists in the younger age-group made no difference as regards the corresponding distributions in the original sample.

In addition, after adjusting the estimates for public- and private-sector dentists by their gender-based weights and for GPs by sector-based weights, only minor alterations occurred. The present results can thus be considered as well representing Finnish dentists' theoretical knowledge for treatment decisions and be generalized to the Finnish GPs in their most active working years.

Questionnaire

Bias in studying treatment decisions is apparent. The strengths of questionnaire surveys are that the investigator is able to formulate the questionnaire to focus it upon the points aimed at. Answering is quick and inexpensive (Chadwick et al. 1984). The results are not biased by observer variation (Uhari 2002), and the sample is easy to make large enough to ensure its representativeness (Mauranen 1999). Further, the respondents are able to answer the questionnaire when they have free time. Limited only by the return deadline, the respondents can weigh their thoughts carefully before answering, and if necessary can interrupt their answering and continue it later.

The drawback of using a questionnaire is that the answers do not necessarily correspond to what the dentists would actually do in real life. Treatment decision for an actual patient mainly consists of dentists' knowledge and previous experience and finally, consideration of whether this information can be applied to the patient in question. The dentists' theoretical knowledge is the basic necessity for optimal treatment decisions, and this was therefore taken as the scope of the present study. After careful consideration of the advantages of several research methods and realising the advantages and limitations of a questionnaire survey (Kuusela and Eskola 1999), as well as the rationale of the survey, the present method was considered to be the most appropriate and reliable approach to gather information about theoretical knowledge for treatment decisions.

The questionnaire was designated according to instructions for a valid questionnaire (Chadwick et al. 1984, Heikkilä 1999). It was relatively brief but described clinical cases in detail, supplemented with radiographs and schematic drawings. The questions were labelled by letters and classified by discipline. Furthermore, the questionnaire included clear instructions for answering. After piloting, based on feedback, some of the questions were reworded.

In addition to the treatment alternatives given, the option of a treatment suggestion was also provided. These free-format answers were used to facilitate the respondents' answering. The number of free-format answers, however, remained small (ranging from 0 to 16) indicating that the treatment alternatives offered were appropriate. Furthermore, responding dentists, as well as pilot dentists, never questioned the fidelity and appropriateness of the clinical cases offered for evaluation; this coincided with earlier findings by Milgrom et al. (1981).

Selection of recommendations

Dentistry is a fast-developing science producing a large amount of up-dated and new information: in the year 2000, for instance, over 20 000 articles were published (Pub Med Search 2003). The quality of clinical practice guidelines is currently under discussion (Bader and Shugars 2002, Jokstad 2003), although it should be based on systematic reviews synthesizing the best evidence, taking into account the preferences of patients and practitioners (Sutherland 2000). In the present study, the primary criteria for selection of guidelines and recommendations were set so as to be consensus-based treatment recommendations, derived from consensus meetings, being thus more structured and formal than those based solely on expert opinion (Sutherland 2000).

The respondents' age-range in the present study was wide, and the time after a dentist's graduation could be up to 20 years. Despite the fact that teaching materials have changed over the years, it is, however, appropriate to assume that the best available material has been used: international textbooks, domestic textbooks, or compendiums.

In teaching of restorative and prosthodontic dentistry, Finnish textbooks and teaching compendiums have played a major role (Koivumaa 1979, 1984, Forsten 1990). In addition, the *Textbook of Cariology* (Thylstrup and Fejerskov 1986) and *Modern Concepts in Operative Dentistry* (Hörsted-Bindslev and Mjör 1988) have served as teaching material from their first editions. In restorative dentistry, however, there do not yet exist exact international treatment recommendations or guidelines.

In periodontology, the Consensus Report from the 1996 World Workshop of Periodontology (CRWPP) (1996) was selected as the basic recommendation because it was developed by a group of international experts. Evidence-based literature reviews provided an extensive analysis of current theory and practice in periodontology, and it has been published in an international journal. In this study of central interest were indications and contraindications for surgical periodontal treatment. These are presented in detail in the international textbooks such as the *Textbook of Clinical Periodontology*, (Lindhe 1990), and *Clinical Periodontology and Implant Dentistry* (Lindhe 1998), and were taken as recommendations. In Finland, the Scandinavian textbook *Parodontologi* (Lindhe 1981) has served as a major reference in dental teaching, based mainly on a common history of research and teaching in Scandinavian periodontology (Jacobson and Theilade 1998).

For endodontology, the ESE report (1994), based on a consensus of international experts and representing current good practice, was chosen as a recommendation because of its two essential elements: appropriateness of treatment modality and quality or level of treatment rendered. In Finnish dental schools, endodontic teaching material has included international textbooks or compendiums, one of these serving as a basis for the first Finnish endodontic textbook "*Käytännön Juurihoito*" (Root canal treatment in practice) by Markus Haapasalo (1998).

For oral implantology, the CDCDI (1988) and CRIT I (1996) were selected as basic recommendations. These were developed by a group of international experts, based on the relevant literature and published at an international level. However, as a discrepancy between recommendations occurs concerning some contraindications for implant surgery, a more conservative approach to treatment contraindications was assumed. Information from Lekholm (1998) was taken into account, because it comes from the same textbook, *Clinical Periodontology and Implant Dentistry* (Lindhe 1998), used in teaching of periodontology and implantology in Finland.

Indicators of dentists' theoretical knowledge

This study reveals the level of dentists' theoretical knowledge for treatment decisions in three disciplines with existing international recommendations and guidelines compared to the optimal treatment decisions derived from international recommendations and guidelines. Thus, each dentist's theoretical knowledge for optimal treatment decisions was considered as the first indicator.

The indicator of dentists' overall competency, the Treatment Decision Competency Score (TDCS), was developed to cover the three disciplines which have existing international recommendations and guidelines. Due to the various numbers of cases presented by discipline, the scores were weighted so that each discipline represented one-third of the TDCS. The TDCS is a hypothetical model giving information on dentists' overall competency in theoretical knowledge, which is required in their every-day practice to inform patients of the optimal treatment options, thus fulfilling the ethical duties of the profession.

Theoretical knowledge for treatment decisions in restorative dentistry

The substantial variation between dentists in theoretical knowledge for restorative treatment decisions in the present study is in line with that of many previous studies (Rytömaa et al. 1979, Elderton and Nuttall 1983, Kay and Locker 1996, Mileman and Espelid 1988). A clear influence of working sector on theoretical knowledge for treatment decisions appeared in the present study: private dentists preferred indirect restorations more frequently than did public dentists. In general, this difference indicates that treatment modalities are influenced by dentist' attitudes and their working environments.

Choosing composite as the filling material for small and medium-sized restorations agrees well with earlier Finnish findings in which composite was selected for over half the fillings in the private sector and 43% in the public sector (Widström and Forss 1994). In recent years, the use of composite has steadily increased, being 75% of all restorations

placed nowadays (Forss and Widström 2001) and dominating also in Iceland, Norway, and Sweden (Mjör 1997a, Mjör et al. 1999, Sundberg et al. 2000, Mjör et al. 2002). Despite the fact that composite restorations have shown reduced longevity compared to amalgam, gold, and ceramic restorations (Jokstad et al. 1994, Mjör 1997b, Roulet 1997, Mjör and Moorhead 1998), the KELA statistics (1997, 1999, 2003) show a continuous increase in the use of composite as restorative material.

The present finding of the decreased role of amalgam restorations is in line with recent findings in Finland: a questionnaire study (Forss and Widström 2001) revealed the use of amalgam to be less than 5% of the restorations, whereas in 1992 it was about 30% (Widström and Forss 1994). This trend of decreasing use of amalgam indicates that Finnish dentists are following the national recommendation that use of amalgam in restorative material should be limited only to those restorations in which use of other materials is not indicated. This has been endorsed by the Ministry of Social Welfare and Health (1994). Although the discussion about amalgam as a restorative material has been actively continuing among health authorities as well as among several expert groups, there is no convincing evidence that the use of amalgam fillings in dentistry has adverse effects on general health (FDI/WHO Consensus Statement 1995, US Public Health Service 1997). Limitations on the use of amalgam also exist in Denmark and Sweden (Bindslev and Sundberg 1999), but in Norway and in Denmark amalgam is still widely used (Mjör et al. 1999, Ylinen and Löfroth 2002), as well as in many other countries (Deligeorgi et al. 2000, Burke et al. 2001). This is due to its longevity and low cost.

The choice of gold as a filling material for larger restorations agrees well with Rykke's (1992) finding that gold was to be recommended for complex restorations. The longevity of gold restorations can be 20 to 50 years (Christensen 1989), they can withstand excessive occlusal forces, and they do not damage the opposite teeth (Nel et al. 1990). Their use has, however, been limited to a few percent of all restorations (Mjör 1997a, Mjör et al. 1999). Reasons for the infrequent use of gold restorations are demanding techniques, poor aesthetics, and high cost. Use of ceramic restorations has increased, combining aesthetic restoration with biocompatibility. Although a few studies also reveal their long-term success-rates as good (Burke and Qualtrough 2000, Bindl and Mormann 2002, Blatz 2002), the Cochrane Review includes only a limited number of well-designed clinical trials, making the study of ceramic restoration longevity difficult (Hayasi and Yeung 2003).

The variation in theoretical knowledge for restorative treatment decisions was obvious. It is notable that although restorative treatment procedures comprised nearly half of all procedures in Finland, with re-restorations more numerous in adult patients than primary restorations, each dentist is allowed to formulate his/her own method of treatment. Some efforts have been made to produce recommendations for placement and replacement of restorations (Anusavice 1989, IADR 1990), and there exists an ongoing project regarding criteria for testing restorative materials (FDI 2003). In the future, establishing scientific basis for restorative treatment and reaching a consensus on restorative treatment decisions should be considered an international challenge for the profession.

Theoretical knowledge for treatment decisions in periodontology

In periodontology, DTs and private dentists preferred surgery. This probably reflects DTs' perceptions of optimal care based on their experience and their working environment. Further, the DTs' ability, their easy access to and their need to become familiar with information in international studies, guidelines, and recommendations may more frequently lead to optimal treatment decisions than is the case with clinicians working in the field. The tendency toward surgery by private dentists is in line with statistics pointing out that periodontal treatment provided in the public sector consists more frequently of simple procedures (Läärä et al. 2000), whereas procedures performed by private dentists are more complicated (KELA 2003). The same national effect may be seen here again. In Finland, private dentists preferred to do all the necessary procedures themselves, including periodontal surgery. Favouring surgery may be a decision influenced by the patient-mix, which in the private sector consists mainly of adult patients, with more complicated periodontal problems.

Finnish dentists' theoretical knowledge for treatment decisions agreed well with recommendations on choosing optimal treatment modality and recognizing contraindications for periodontal surgery. It was interesting to note that more than half the dentists recommended periodontal surgery for a smoker, in agreement with international recommendations. Although smoking modifies the subgingival microbiota, causes an increase in the prevalence of certain pathogens (CRWWP 1996), and influences wound healing and immune and inflammatory responses (Lindhe 1998), it is still considered only a relative contraindication for periodontal surgery. Although smoking is a common phenomenon in Finland (23%) (Helakorpi et al. 2003), dentists do not consider smoking a contraindication for surgery today. Finnish dentists agree, however, that dentists should take part in anti-tobacco health education (Telivuo et al. 1991).

Theoretical knowledge for treatment decisions in endodontology

In endodontology, notable variation has been detected between dentists' treatment decisions as to re-treatment of asymptomatic, periapical lesions in endodontically treated teeth (Reit and Hollender 1983, Reit and Gröndahl 1984, Lambrianidis 1985, Reit et al. 1985, Reit and Gröndahl 1988). In the present study, however, theoretical knowledge for treatment decisions by dentist groups was quite similar: a difference was detectable in only one case in four, with private dentists preferring active treatment more frequently than public dentists and DTs. Active treatment was seldom recommended in cases with underfilled root canals and a widened periodontal ligament space or in cases with short-duration pain. This result is in line with German questionnaire findings that non-intervention or further radiographic monitoring are still preferred by the majority of

general practitioners in cases that include teeth with periapical radiolucencies, pain, and under- and overfilled root canals (Hülsman 1994). Dentists working with patients may have experience showing that re-treatment does not necessarily bring any better outcome. These results may reflect the fact that despite the development of new technologies, endodontic re-treatment is demanding and time-consuming work for dentists, and expensive for the patient.

In this study, the majority of dentists agreed with the recommendations by the ESE (1994), although dentists disagreed with the ESE recommendations for a patient with short-duration pain and a widened periodontal ligament. They seemed to ignore the patient's symptoms and base their treatment decision mainly on radiological findings. This wide agreement with the recommendations may be an indication that Finnish dentists have every chance to succeed in providing good quality endodontic treatment to their patients. According to present results, Finnish dentists have sufficient know-how to maintain the quality of endodontic treatment at a high level. Treatment practices will, however, vary between dentists, not always producing the optimal picture of endodontic treatment (Helminen 2000).

Theoretical knowledge for treatment decisions in oral implantology

In recent years, osseointegrated dental implants have been increasingly successfully used to replace a missing tooth in the anterior region (Ekfeldt et al. 1994, Creugers et al. 2000, Henry 2000). In the future, the use of implants is expected to expand (Österberg et al. 2000, Pihakari et al. 2001) but at only a moderately low rate unless education in this process increases (Levin 2002). Levin found in his interview study that in a given year, 80% of general dentists felt to some degree confused about dental implant diagnosis and treatment, and accordingly, 60% did not refer for restoration or themselves restore one single implant. Although in the year 2000, Finnish private dentists placed the majority of dental implants (Pihakari et al. 2001), the present study revealed that awareness of contraindicated patients among Finnish GPs overall was rather good. This finding is very promising from the perspective of patients' becoming more well-informed by their dentists, regardless of working sector. On the other hand, this might not be the case in the global perspective (Levin 2002).

The present study revealed that Finnish dentists' theoretical knowledge for treatment decisions in implantology mostly agreed with international recommendations and guidelines. Poorly controlled diabetes was the most frequently chosen contraindication for implant therapy by all dentist groups, in agreement with international recommendations. This may reflect dentists' attitudes towards diabetes as a serious, quite rare, systematic problem requiring consultation with a physician. For patients with well-controlled diabetes, however, implant therapy can be recommended (Shernoff et al. 1994, Balshi and Wolfinger 1999, Fiorellini et al. 2000, Olson et al. 2000), preferably along with antibacterial

prophylaxis (Hall et al. 1994, Dent et al. 1997). Although many studies have revealed a significant difference in implant failures between smokers and non-smokers (Bain and Moy 1993, De Bruyn and Collaert 1994, Wallace 2000), smoking is considered only a relative contraindication for implant therapy (CRIT I 1996, Lekholm 1998). According to the present results, the majority of Finnish dentists did not act in accordance with this recommendation and preferred no implant therapy for smokers. Another present finding, not to recommend implant therapy for a patient with untreated caries lesions or with periodontal pockets, may be an indication of Finnish dentists' careful attitude towards the expensive treatment they provide and thus probably indicates very careful patient selection for implant therapy. These results agree with Butterworth et al. (2001) who found that the majority of consultants in restorative dentistry consider poor oral hygiene, uncontrolled caries, and periodontal disease to be the most important oral factors influencing patient selection for implant therapy.

Dentists' characteristics in decision-making

Practice characteristics influence treatment decisions (Grembowski et al. 1990), as also do technical factors (Grembowski et al. 1988), but the present results are in accordance with findings that dentist-related factors explain little of the variation in theoretical knowledge for treatment decisions (Kronström et al. 1999b).

The working sectors' influence on theoretical knowledge for treatment decisions was obvious in the present study in each discipline, as has earlier been pointed out in radiological decision-making (Wenzel and Moystad 2001), as well as in restorative dentistry (Widström and Forss 1994). This influence was even expected: the main point was, however, that with a well-planned research instrument, the influence of professional experience and working sector would decrease. From the patient's point of view as well as from the viewpoint of the dental delivery system, the most essential goal is that the patient gets the best possible treatment.

Our dentists' overall competency, described as a weighted score for optimal treatment decisions in the three disciplines with existing international recommendations and guidelines, was at an acceptable level. Although the impact of continuing education on TDCS was surprisingly weak, CE played an important role in enhancing dentists' knowledge in three of the four disciplines studied. This is in accordance with the fact that following educational intervention, dentists' decisions are less variable and more accurate (Choi et al. 1998). Further, in CE courses, dentists become aware of the complexity of the procedures involved and tend to actively participate in the prosthetic reconstruction of simple cases (Brandt et al. 2000). Our measurement of CE had to be only general, because there are several ways to participate in CE. In Finland, CE activity is revealed to be high (Murtomaa et al. 1990).

The present study detected the influence of dentist's gender in theoretical knowledge for treatment decisions in two of the four disciplines: periodontology and oral implantology. Difference in treatment decisions between genders was detected also by Kronström et al. (1999b), who found that in their prosthodontic treatment decisions, female dentists considered the patient's general health as of greater importance than did male dentists. Further, female dentists placed a greater emphasis on patient age than did males (Kronström et al. 1999a). These gender influences on dental treatment decisions are opposed to the findings of Trovik et al. (2002) that dentists' gender, age, and working sector had no effect on dentists' recommendation to replace missing teeth.

SUMMARY

Optimal treatment decisions in dentistry are a synthesis of information about patient characteristics, patient wishes, and dentists' updated knowledge of treatment decisions - knowledge derived from international or national databases as well as from existing treatment recommendations and guidelines for good clinical practice.

The aim of the present study was to investigate dentists' theoretical knowledge for treatment decisions in restorative dentistry, periodontology, endodontology, and oral implantology. The variation in theoretical knowledge for treatment decisions between public dentists, private dentists, and dental teachers was evaluated in each discipline. Further, such theoretical knowledge was compared to existing international treatment recommendations and guidelines. A Treatment Decision Competence Score (TDCS) was developed to describe dentist's overall competency in making optimal treatment decisions.

The study was carried out by use of a pre-tested postal questionnaire mailed to general practitioners (n=400) selected by stratified randomisation among members of the Finnish Dental Association, and to all full-time dental teachers (n=47) in all dental schools in Finland representing clinical disciplines other than orthodontics and surgery. The sample of GPs covered dentists aged 30 to 49 years, and eight clusters (n=50) were formed according to main employment (public or private sector), gender, and age (30-39 or 40-49 years).

The questionnaire inquired about dentists' work-related and personal background, including respondent's gender, age, university of graduation, professional working experience, main employment, province of practice, and location of practice. Further, type of practice, working alone or with a dental assistant, specialised licence, number of continuing education days in the preceding year, and proportion of adult patients were also determined from the questionnaire.

The results revealed that the variation in theoretical knowledge for treatment decisions in the three dentist groups was largest in restorative dentistry and in oral implantology. In restorative dentistry, the variation in such theoretical knowledge appeared mainly in cases of medium-sized and large restorations, where the private dentists and dental teachers more frequently preferred indirect restorations than did the public dentists. In implantology, case by case, implant therapy was recommended more frequently by private dentists than by public dentists, and in the one or two of cases, more frequently than by

dental teachers. In periodontology, the largest variation in theoretical knowledge for treatment decisions between dentist groups appeared when groups chose treatment for a patient with one deep periodontal pocket or chose treatment for a smoker. In endodontology, the main difference in theoretical knowledge between dentist groups occurred in one case of four: private dentists more frequently chose active treatment (endodontic re-treatment or periapical surgery) than did public dentists and dental teachers for the case with an asymptomatic tooth, an underfilled root canal, widened periodontal ligament space, and no radiolucency.

The Finnish dentists' theoretical knowledge for treatment decisions mostly agreed with existing international recommendations and guidelines. In the field of periodontology, in six of seven treatment decisions and in endodontology in three of four decisions, most of the dentists followed treatment recommendations. In implantology, the majority of dentists' theoretical knowledge for treatment decisions recommending implant therapy for patients with various contraindications agreed with recommendations in seven of ten cases.

The influence of dentists' characteristics on theoretical knowledge for treatment decisions was studied separately for each discipline: the higher number of continuing education days was associated in restorative treatment with a preference for indirect restorations, in periodontology with a preference for surgery, and in implantology with a preference for implant therapy for patients with oral and medical contraindications. Dentist's gender made a difference in implantology: male dentists recommended implant therapy more frequently for the patient with a cardiac infarction, an endoprosthesis, or age over 70 than did female dentists. Further, according to the TDCS, male dentists working in the private sector chose optimal treatment decisions more frequently than did other groups, including dental teachers.

CONCLUSIONS AND RECOMMENDATIONS

The Finnish dentists' theoretical knowledge for treatment decisions varied by working sector, thus giving no support to the first hypothesis; but did not vary by dentists' work-related and personal characteristics, which supports the second hypothesis. In addition, the majority of dentists knew the international treatment recommendations and guidelines, supporting the third hypothesis.

Variation in theoretical knowledge for treatment decisions by the three dentist groups was largest in restorative dentistry and in oral implantology; private dentists and dental teachers more frequently preferred indirect restorations and in most cases, implant therapy for their patients than did public dentists. The Finnish dentists mostly agreed with the existing international treatment recommendations and guidelines, and dentists' characteristics seemed to have only a minimal impact on theoretical knowledge for treatment decisions. Despite these positive findings, there still is space for improvement in dental treatment decisions.

The results indicate the need to improve and standardise dentists' treatment decisions. First of all, dentists should assume an active and decisive role in assessing their knowledge regarding different treatment alternatives. A basis for life-long learning should develop during dental education. After graduation, an active role in assessing and updating new information should be considered as an important part of dentists' daily work, being a prerequisite for optimal treatment decisions.

The development of recommendations and guidelines, both national and local, in each of the common dental disciplines could optimise treatment decisions, establishing a basis for high-quality dental treatment. This should be considered an important challenge for the dental profession.

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